Competition

The iGEM competition is first of all a competition between the different iGEM teams. The teams have to compete against each other in different age categories and tracks. The best project in each track and category is awarded a prize. Furthermore, there are special prices for, for example, best human practices, best wiki and best part. Finally, the most valued prize for every team is the Grand Prize. This is the prize for the overall best project. Although a limited number of teams can win an award, every team can achieve a bronze, silver or gold medal. For every medal, the team has to meet specific requirements about among other things parts they have to register, collaborations and human practices.

In this part of the report, the competition itself is analyzed. Firstly, quantitative and qualitative data is collected about the competition itself. After this we have critically analyzed the competition and have especially focused on potential inequality within the iGEM competition.

Qualitative & Quantitative analysis

Participants

As described before, the iGEM competition, as we know it today, began life in 2006. Back in those days, there were 32 participants. Ever since then the number of participating teams has increased and with 280 teams in 2015, the number of teams has increased almost nine fold in 10 years (Figure 1).

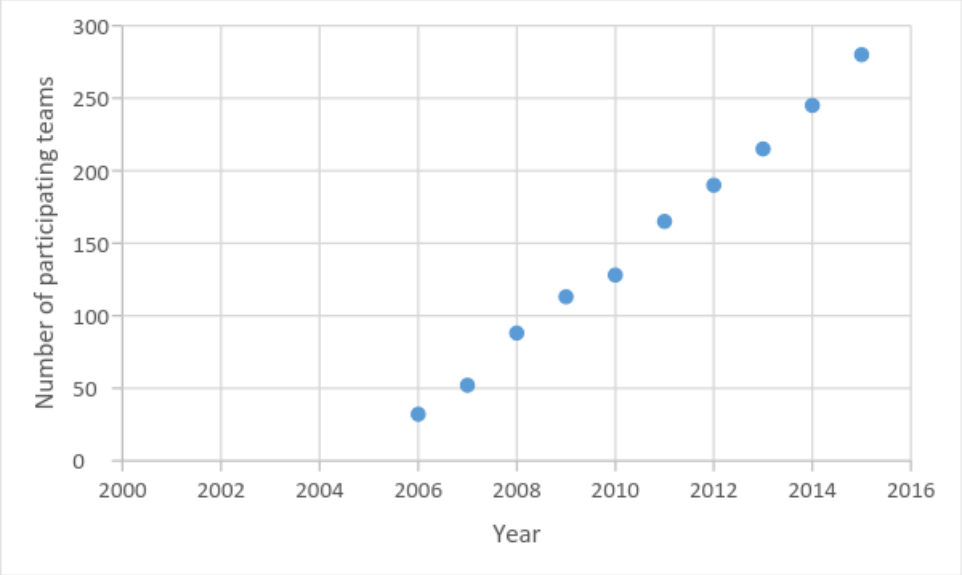

Figure 1: The number of participating teams.

In the beginning of the competition, the teams were mostly coming from North-America. Over the years this has been changed and since 2008, less than half of the teams is coming from North-America (Figure 2). This shift is mainly the result of the relative increase of participation teams from both Europe and Asia. Especially the relative share of Asia is increased enormously. On the other hand, the share of African teams is severely underrepresented. Only in 2010 and 2015 there where participants from the African continent and in both years this was only 1% of the total teams.

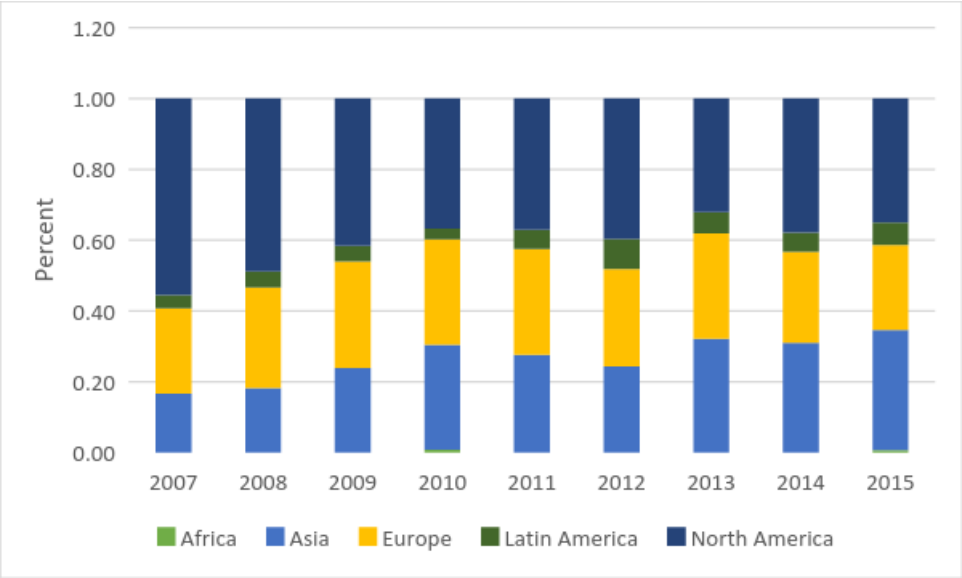

Figure 2: Relative share of the continents in the competition. There is no reliable data available about 2006.

The total number of participants is increased over the years, as expected, while the average number of participants per team fluctuates (Figure 3).

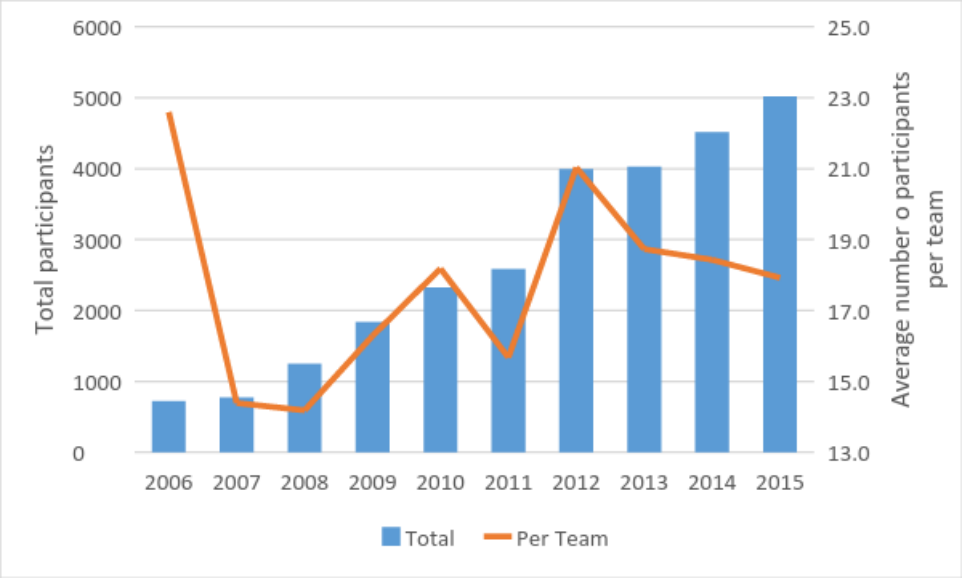

Figure 3: Total number of participants and the average number of participants per team.

The Tracks

Since 2009, iGEM teams have to participate in a specific track. The tracks allow teams to focus their project towards a specific subject area within synthetic biology and allow them to know who they will compete against for the track award. They started with 8 different tracks; respectively the tracks Environment, Food/Energy, Foundational Advance, Health/Medicine, Information, Processing, Manufacturing, New Application and Software Tools. In 2013, the ninth track, called Entrepreneurship, was officially introduced after a pilot year in 2012. The goal of this track is to foster development of a new industry where Synthetic Biology is the underlying technological platform. In 2014 it is decided to drastically change the tracks. *"The idea behind separating out Tracks and New Tracks is to highlight that the there are differences in the scope of work and also in the evaluation."*(iGEM, 2014) The track Food/Energy was replaced by the two separated tracks Food/Nutrion and Energy. Furthermore, the tracks Community Labs, Measurement, Microfluidics and a separated track for Policy & Practices have been added. Also, since 2014, there is a special track about the art of synthetic biology, named Art & Design. In 2015 they have decided to stop the Microfluidics track because it is narrow and instead of this track, they have introduced the track Hardware in which microfluidics is included. Furthermore, after running an experiment for three years, the track Entrepreneurship is no longer a track. Because it is believed that every team, irrespectively from the track, could write a business plan and therefore a special prize about entrepreneurship is introduced. Finally, after organizing a separate competition for high school teams for a few years, it is possible for them to participate in the regular iGEM competition since 2015.

The number of teams participating in every track in the years 2009 until 2015 can be found in Table 1.

Table 1: Number of teams participating in every track in the years 2009-2015.

Track	2009	2010	2011	2012	2013	2014	2015
Environment	16	16	25	30	36	45	33
Food/Energy	8	12	15	22	25	-	-
Foundational Advance	21	20	26	34	29	27	21
Health/Medicine	15	20	13	26	40	43	55
Information Processing	8	6	10	13	12	13	11
Manufacturing	14	17	15	11	13	14	18
New Application	13	20	31	28	24	26	31
Software Tools	8	6	8	10	8	11	8
Entrepreneurship	-	-	-	-	4	3	-
Art & Design	-	-	-	-	-	5	3
Community Labs	-	-	-	-	-	6	4
Energy	-	-	-	-	-	11	13
Food/Nutrition	-	-	-	-	-	9	13
Measurement	-	-	-	-	-	10	7
Microfluidics	-	-	-	-	-	2	-
Policy & Practices	-	-	-	-	-	2	-
Hardware	-	-	-	-	-	-	7
High schools	-	-	-	-	-	-	36

The Medals

One of the special things about the competition is that every team can earn a medal. Every year there are specific requirements to win a bronze, silver or a gold medal. In this part the medal requirements over the past five years are analyzed.

Bronze

In the year 2011, the requirements to win a bronze medal were:

- Team registration
- Complete Judging form
- Team Wiki
- Present a poster and a talk at the iGEM Jamboree
- At least one new submitted and well-characterized standard BioBrick Part or Device. A new application of and outstanding documentation (quantitative data showing the Part's/ Device's function) of a previously existing BioBrick part in the "Experience" section of that BioBrick's Registry entry also counts.

In the three following years, these requirements did not change in content. However, in 2014 a new requirement was added to the list:

- The description of each project must clearly attribute work done by the students and distinguish it from work done by others, including host labs, advisors, instructors, sponsors, professional website designers, artists, and commercial services. Please see the iGEM 2011 Imperial College Acknowledgements page for an example.

Silver

In addition to the Bronze Medal requirements, the requirements to win a silver medal were in 2011:

- Demonstrate that at least one new BioBrick Part or Device of your own design and construction works as expected.
- Characterize the operation of at least one new BioBrick Part or Device and enter this information in the "Main Page" section of that Part's/Device's Registry entry.

Two extra requirements were added in 2013:

- Submit this new part to the iGEM Parts Registry (submissions must adhere to the iGEM Registry guidelines).
- Your project may have implications for the environment, security, safety and ethics and/or ownership and sharing. Describe one or more ways in which these or other broader implications have been taken into consideration in the design and execution of your project.

In 2015 they reorganized the four requirements into three new requirements:

- Experimentally validate that at least one new BioBrick Part or Device of your own design and construction works as expected. Document the characterization of this part in the Main Page section of the Registry entry for that Part/Device. This working part must be different from the part you documented in Bronze medal criterion.
- Submit this new part to the iGEM Parts Registry. This part must be different from the part you documented in Bronze medal criterion. (Submissions must adhere to the iGEM Registry guidelines.)
- iGEM projects involve important questions beyond the bench, for example relating to (but not limited to) ethics, sustainability, social justice, safety, security, and intellectual property rights. We refer to these activities as Human Practices in iGEM. Demonstrate how your team has identified, investigated and addressed one or more of these issues in the context of your project.

Gold

In 2011 every team had to meet, in addition to the Bronze- and Silver Medal requirements, one or more of the following requirements, in order to receive a gold medal:

- Improve the function of an existing BioBrick Part or Device (created by another team or your own institution in a previous year) and enter this information in the Registry (in the "Experience" section of that BioBrick's Registry entry), and don't forget to create a new registry page for the improved part.
- Help another iGEM team by, for example, characterizing a part, debugging a construct, or modeling or simulating their system.
- Outline and detail a new approach to an issue of Human Practice in synthetic biology as it relates to your project, such as safety, security, ethics, or ownership, sharing, and innovation.

In 2013, a small change is made in the last optional requirement to win a gold medal:

- Your project may have implications for the environment, security, safety and ethics and/or ownership and sharing. Describe a novel approach that your team has used to help you and others consider these aspects of the design and outcomes of synthetic biology efforts. Please justify its novelty and how this approach might be adapted and scaled for others to use.

In 2014 this last requirement is further tightened:

- iGEM projects involve important questions beyond the bench, for example relating to (but not limited to) ethics, sustainability, social justice, safety, security, or intellectual property rights. Describe an approach that your team used to address at least one of these questions. Evaluate your approach, including whether it allowed you to answer your question(s), how it influenced the team's scientific project, and how it might be adapted for others to use (within and beyond iGEM). We encourage thoughtful and creative approaches, and those that draw on past Policy & Practice (formerly Human Practices) activities.

The requirements are changed again in 2015. Since this year, in addition to the Bronze and Silver Medal requirements, the teams has to convince the judges it has achieved at least two of the following goals:

- Choose one of these two options: (1) Expand on your silver medal Human Practices activity by demonstrating how you have integrated the investigated issues into the design and/or execution of your project. OR (2) Demonstrate an innovative Human Practices activity that relates to your project (this typically involves educational, public engagement, and/or public perception activities; see the Human Practices Hub for information and examples of innovative activities from previous teams).
- Help any registered iGEM team from a high-school, different track, another university, or institution in a significant way by, for example, mentoring a new team, characterizing a part, debugging a construct, modeling/simulating their system or helping validate a software/hardware solution to a synbio problem.
- Improve the function OR characterization of a previously existing BioBrick Part or Device (created by another team, or by your own team in in a previous year of iGEM), and enter this information in the part's page on the Registry. Please see the Registry Contribution help page for help on documenting a contribution to an existing part. This part must not come from your team's 2015 range of part numbers.
- Demonstrate a functional prototype of your project. Your prototype can derive from a previous project (that was not demonstrated to work) by your team or by another team. Show this system working under real-world conditions that you simulate in the lab. (Remember, biological materials may not be taken outside the lab.)

Number of medals

Figure 4 shows the percentage of teams with respectively no medal, a bronze medal, a silver medal or a gold medal.

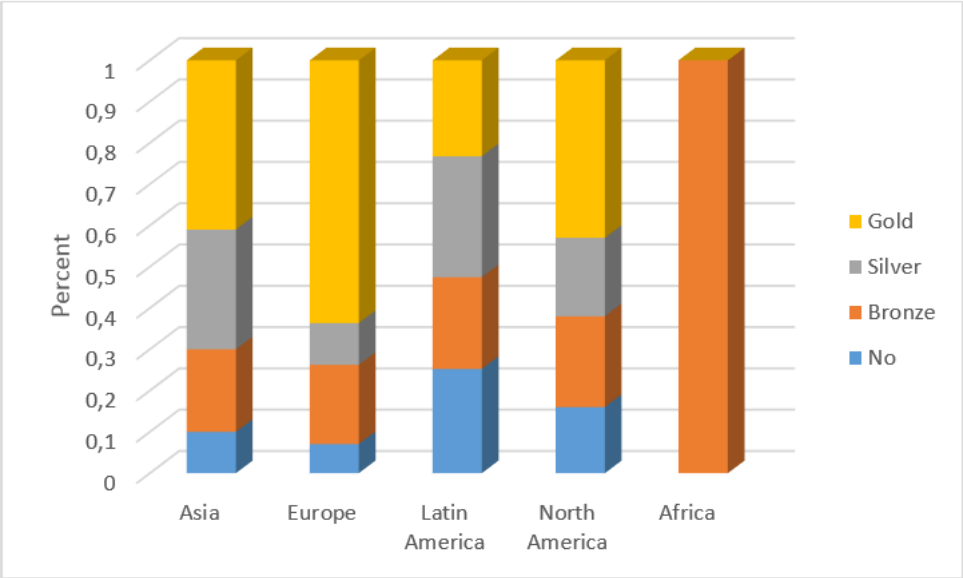

Figure 4: Total medal distribution. The percentage of teams with respectively no medal, bronze medal, silver medal or a gold medal.

Critical analysis

Based on the statistical data it appears that the medal requirements are mainly focusing on science and policy and practice. This is understandable, since the iGEM competition is all about the use of synthetic biology in a socially responsible way. However, in our opinion, for example modeling can be considered as an important part of the competition as well. After all, mathematical models and computer simulations provide a great way to describe the functioning and operation of BioBrick Parts and Devices. Therefore, we think modeling has to be included in the medal requirements as well.

Currently, modeling is not a required part of the competition; therefore many teams do nothing with it. Probably, this is partly because many teams have no members with experience in modeling. These teams would be extremely disadvantaged if modeling becomes a hard requirement. Therefore, we propose to add an extra possible requirement that teams can meet to win a gold medal:

“Construct a mathematical model to aid in the design, understanding, and/or implementation of your project. Validate your model with measurements.”

This could give teams an extra motivation to use models in their project.

Another interesting point is the fact that over the years the medal requirements have become harder. Nowadays it is more difficult to win a medal. However, relatively many teams are still able to win a medal. After all, almost 90% of the teams wins at least a bronze medal. This raised the question whether the medal requirements are too soft. To analyze this proposition, we have asked the opinion of the headquarters. They told us that teams are not competing with each other for medals, so if every team convinced the judges that they had achieved the requisite level for a gold, they would give them all gold. They want teams to care about the things that matter to iGEM, such as openness, communication, sharing and thinking about the effect of your work on the world and the world on your work.

In their opinion every team has to be able to win a medal and all teams are judged subject to the same criteria. For new teams, teams from resource poor countries and high school teams without a -80 degree Celsius freezer it appears to be difficult to meet the requirements for a medal. Another important reason to not make the requirements too hard, a medal can give a boost for fundraising. Teams that win a medal, and especially teams that win a gold medal, will probably be able to obtain more funds in the year afterwards. This benefits the projects.

Based on the analysis we believe that it is not wise to drastically change the medal requirements in order to decrease the number of teams with a medal. The headquarters clearly stated that the goal of the medals is to make sure that iGEM teams focuses on the aspects they believe to be important. Also, the potential positive influence of a medal on fundraising is an important reason we think the medal requirements should not be too hard. However, we do believe that it is important to update the requirements every year. Among other things, new technology developments will make it easier to meet certain requirements. Therefore, just as in the past few years, the requirements have to be adapted every year and if required they have to be tightened.

Inequality within the competition

Within the competition there are a few aspects that are not the same for all the teams. This means that there is a form of inequality within the competition. In this part a few of the potential inequalities are evaluated.

The budget

One of the aspects that probably always has a significant influence on the success of a research project, is the budget. The differences in available budget between teams are expected to be large. This raises the question whether measures should be taken to reduce disparities. For example, setting an upper limit to the budget or dividing teams based on budget in different subdivisions could be an option.

Based on the survey it appears that the difference in budget are significant large. The survey responder with the smallest budget had a budget of around 500 euro, which is almost 10 times smaller than the responding team with the largest budget that had a budget of around 50.000 euro.

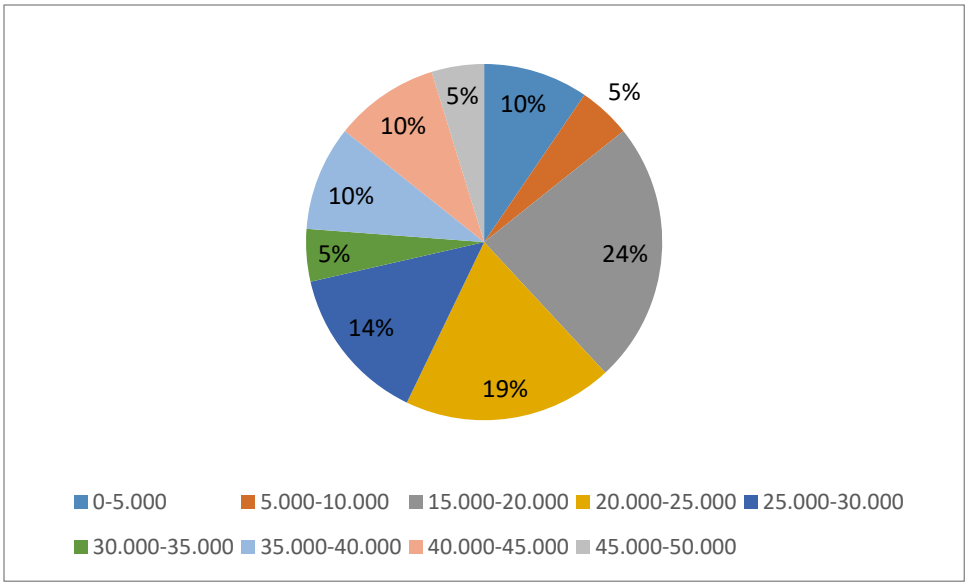

Figure 5: Budget distribution of the iGEM teams. Data based on the teams that have filled out the survey.

It has to be mentioned that the average budget of responding overgrad teams was slightly higher than the average budget of the undergrad teams. However, the differences within both groups were still in the order of magnitude of 30.000 euro. It appears that there is a relation between the medals and the budget of the teams. Most of the teams with a large budget also win a gold medal. Among the teams with a relatively small budget, the number of teams that has no medal is significant higher. Also the "chance" to win an award appears to be higher when the team has a large budget.

Based on this data it is not possible to conclude that there is a direct cause-effect relation between budget and results. For example, it is in theory also possible that the budgets of the winning teams are larger because of the fact that their project is very interesting. This could make finding funds easier. However, as described before, these enormous differences raise the question whether measures should be taken to level the resource. Therefore, the possibilities to take measures with respect to the budgets are analyzed.

The first proposal is to set a maximum budget. The main advantage of such a measure is the fact that the differences in budget will be narrowed and teams will have more equal opportunities therefore. Especially for teams with a small budget it could give them the feeling they are not hopeless participants. However, there are many objections to this proposal. First of all, it is almost impossible to exercise real control. Partly because such a control is based solely on trust. Teams could easily manipulate information about their budget. Secondly, it is questionable whether the budget could be considered as the only resource of a team. For example, the research facilities of a university play also an important role in the opportunities of a team. In our opinion, all of this will make it almost impossible to set a maximum budget.

A second possibility could be to set a minimum budget. This will, likewise a maximum budget, narrow the differences in budget. This will result in a situation where some teams are not able to participate in the competition anymore. This is not desirable in our opinion. Currently teams can decide for themselves whether it is meaningful to participate or not. An external party should, in our opinion, not decide this for them.

Another, totally different approach could be to fairly divide the available budget of all the teams between all the teams. However, this will also not solve the problem of the aforementioned differences in research facilities. Furthermore, this will probably impede raising funds. For example, many sponsors will only sponsor a specific university or local party and in many cases teams have specific sponsors for their project. Finally, it would be possible to divide teams, based on their budget, in different subclasses. Unfortunately, this will also be uncontrollable as well.

All the aforementioned possibilities implicate that narrowing the differences in the budget would be an improvement for the competition. However, fundraising could also be considered as part of the competition. Teams with a higher budget are apparently better in fundraising. Furthermore, it is expected that the possibilities for funding are partly depending on the research project of a team. A good research proposal and an interesting research topic will probably facilitate fundraising.

Another interesting question to ask is what is more important for the iGEM competition, equality between teams or the eventual results of the teams. When the results of the teams and therefore the success of the research projects are more important, it is not desirable to limit teams in their budget. This will in many cases not benefit the results of the project.

In our opinion the research project is the most important aspect of the competition. Teams should therefore not be limited in their budget. Instead of limiting 'wealthy' teams, the competition could better promote 'less wealthy' teams. Partly, this is already the case. For example, all participants get free access to Snapgene and Matlab. Furthermore, after paying the required fee, all teams have access to many DNA parts. This gives teams with fewer facilities also the possibility to participate. However, in our opinion the promotion of less wealthy or in more general, less experienced teams could be better. For example, the iGEM competition could start a more extensive coaching program. This can be done in different formats. Firstly, it is possible that inexperienced teams are coached by more experienced teams. This could be one of the possible requirements to win a gold medal. Then both teams can profit from it. Another possibility is to require overgrad teams with more experience students to coach new and inexperienced undergrad teams. It is also possible to use a team of experienced researchers to coach teams. Furthermore, a more committal initiative could be to use the forum in order to coach teams. Teams could ask help on the forum and other teams or experts can help them. To make this profitable for both teams, we propose a point system. Teams that help other teams can earn points and when they achieve a certain number of points, they could for example use this to meet one of the requirements to win a gold medal. Eventually, all these proposals hopefully result in a higher level across the spectrum of teams.

Travel costs

The travel costs between the different teams are large. Teams from for example Boston, New York or Philadelphia can travel for 50 to 100 euro per person while teams from Australia probably need 1000-1500 euro per person for traveling (Figure 6).

Figure 6: Traveling costs

From 2011 to 2013 the competition was split into three regions, respectively Europe, Asia and the Americas. Only the best teams from every region were allowed to go to Boston for the finals. The reason to have regional competitions was because of the increasing size of the Jamboree. In 2014, the organization hosted a giant jamboree so every team could participate in one conference. This has as main advantage that all the teams can meet each other, discuss their projects and eventually watch live the presentations of the final teams. However, the above mentioned differences in traveling costs result in an inequality within the competition. For teams from Australia, traveling will probably a large part of their budget, while for teams from North America this is probably not the case. Reintroduction of the region competition would partly solve this problem. However, for the teams that reach the finals, the problem will still remain.

We believe that the possibility to interact with teams from all over the world during the jamboree is more valuable than disadvantages of the inequality within the competition as a result of the differences in travel costs. Nevertheless, it cannot be declined that the differences in travel costs also result in an inequality within the competition.

Laws and policies

From European Union to Africa, China and Japan and all the way back to the U.S.A, various bans, laws, and labels can make synthetic biology difficult to keep up with. The differences possibly also result in an inequality within the competition.

In this report we will not especially compare legal differences between different countries. Interested readers can look into the analysis made by the Arizona State iGEM team from 2013. We will purely focus on the problems that the responders of the survey have encountered.

Based on the survey it appears that several teams had legal issues. About 30% of the teams encounter problems. From the teams that did encounter problems, multiple of them have mentioned that they did encounter problem because of uncertainties in the law about synthetic biology and SynBio products. It appears that in many countries the regulation about these subjects is not up to date or even almost absent. Therefore, there are many teams that operated in a grey area. One of the teams eventually decided to contact the government about this and they succeeded to start a collaboration with the government. Based on advises of this team, the government is currently chancing the regulation about synthetic biology. In our opinion this forms a nice example of potential volubility of iGEM.

Another interesting point is the fact that one of the teams mentioned that they worked with transgenic plants and that they have experienced that in Europe transgenic plants are rejected in advance by society and government. Even if there are no arguments and the product is safe, it is not allowed to use them. The fact that synthetic biology is rejected by governments purely because of fear, is something that more teams have mentioned.

Based on the survey it appears that most of the teams have no legal issues worth mentioning. However, there are also multiple teams that experienced legal problems because of incomplete legislation or because of general aversion against synthetic biology. The example of the team that started a collaboration with the government shows that iGEM could play an important role in this.